DETAILED SOLUTIONS

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MPSC 2019 : Main Exam
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 9

Full Syllabus Test-3 | Paper-I

ANSWER KEY

1.	(c)	18.	(b)	35.	(c)	52.	(a)	69.	(d)	86.	(b)
2.	(b)	19.	(a)	36.	(d)	53.	(d)	70.	(d)	87.	(b)
3.	(a)	20.	(b)	37.	(c)	54.	(b)	71.	(c)	88.	(a)
4.	(c)	21.	(d)	38.	(c)	55.	(c)	72.	(d)	89.	(d)
5.	(b)	22.	(b)	39.	(c)	56.	(b)	73.	(b)	90.	(a)
6.	(d)	23.	(c)	40.	(b)	57.	(a)	74.	(a)	91.	(b)
7.	(a)	24.	(b)	41.	(a)	58.	(c)	75.	(b)	92.	(b)
8.	(c)	25.	(c)	42.	(a)	59.	(b)	76.	(c)	93.	(c)
9.	(d)	26.	(c)	43.	(b)	60.	(b)	77.	(d)	94.	(c)
10.	(a)	27.	(d)	44.	(a)	61.	(c)	78.	(a)	95.	(a)
11.	(c)	28.	(a)	45.	(c)	62.	(c)	79.	(b)	96.	(b)
12.	(c)	29.	(b)	46.	(a)	63.	(a)	80.	(d)	97.	(c)
13.	(a)	30.	(a)	47.	(b)	64.	(b)	81.	(a)	98.	(c)
14.	(c)	31.	(d)	48.	(a)	65.	(a)	82.	(c)	99.	(a)
15.	(c)	32.	(a)	49.	(c)	66.	(c)	83.	(b)	100.	(c)
16.	(b)	33.	(b)	50.	(a)	67.	(d)	84.	(d)		
17.	(d)	34.	(a)	51.	(a)	68.	(b)	85.	(b)		

DETAILED EXPLANATIONS

1. **(c)**

As per IS: 456-2000

Partial safety factor for concrete = 1.5

Partial safety factor for steel = 1.15

4. **(c)**

As per IS : 456 - 2000, Clause 8.2.8

Concrete in sea water or exposed directly along the sea cost shall be atleast M20 grade concrete in the case of plain concrete and M30 grade concrete in case of reinforced concrete.

5. **(b)**

$$\text{For M20, } \tau_{c,\,max} = 2.8 \text{ N/mm}^2$$

$$\tau_v = \frac{V_u}{bd} = \frac{120\times10^3}{230\times400} = 1.3 \text{ N/mm}^2 \not> \tau_{c,\,max}$$

$$\tau_c = 0.48 \text{ N/mm}^2$$

$$\tau_v > \tau_c$$

Design shear force,

$$V_{us} = V_u - V_c = (\tau_v - \tau_c)bd = (1.3 - 0.48)\times230\times400\times10^{-3} = 75.44 \text{ kN}$$

Now,

$$V_{us} = \frac{0.87 f_y A_{sv} \cdot d}{S_v}$$

$\therefore$

$$s_v = \frac{0.87\times250\times2\times\frac{\pi}{4}(8)^2\times400}{75.44\times10^3} = 115.93 \text{ mm} \simeq 115 \text{ mm}$$

$$S_v \le \min.\begin{cases} 115\,\text{mm} \\ 0.75d = 0.75\times400 = 300\,\text{mm} \\ 300\,\text{mm}\end{cases}$$

$$\simeq 115 \text{ mm}$$

6. **(d)**

The check for $\tau_{c,\,max}$ is required to take care of possibility of crushing of concrete by diagonal compression.

7. **(a)**

As per IS: 456 – 2000 clause 41.4.2.

The longitudinal reinforcement shall be designed to resist an equivalent bending moment.

$$M_e = M_u + M_t = M_u + \frac{T_u\left(1+\frac{D}{b}\right)}{1.7}$$

M_u = Bending moment at the cross-section

T_u = Torsional moment

D = Overall depth of the beam

b = Breadth of the beam

8. (c)

Lap length of compression:

As per IS 456-2000, 26.2.5.1(d)

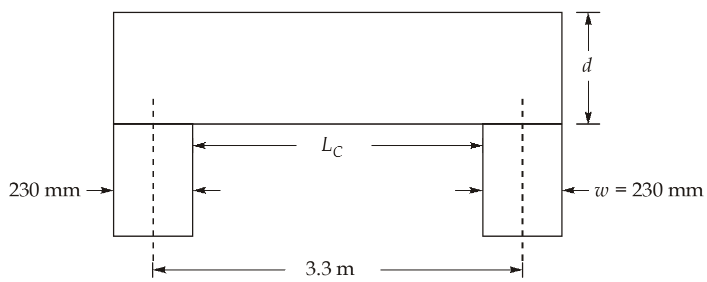
The lap length in compression shall be equal to the development length in compression but not less than 24ϕ.

Lap length in tension:

As per IS 456-2000 26.2.5.1.(c)

- For flexural tension-L_d or 30ϕ (which ever is greater).
- For direct tension-2L_d or 30ϕ (which ever is greater).

9. (d)



$$\text{Clear span} = (L_c) = 3.3 - w = 3.3 - 0.23 = 3.07 \text{ m}$$

$$\text{Effective span} = \min.\begin{cases} L_c + d \\ c/c \text{ spacing} \end{cases} = \min.\begin{cases} 3.07 + 0.08 = 3.15\,\text{m} \\ 3.3\,\text{m} \end{cases} = 3.15 \text{ m}$$

11. (c)

As per IS 456-2000, the final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members should not normally exceed span/250.

The deflection including the effects of temperature, creep and shrinkage occurring after erection of partitions and the application of finishes should not normally exceed $\frac{\text{span}}{350}$ or 20 mm whichever is less.

12. (c)

$$\text{Spacing} = \frac{1000 \times a_s}{A_{st}}$$

$$10 = \frac{1000 \times \frac{\pi}{4}(10)^2}{A_{st}} \quad ....(1)$$

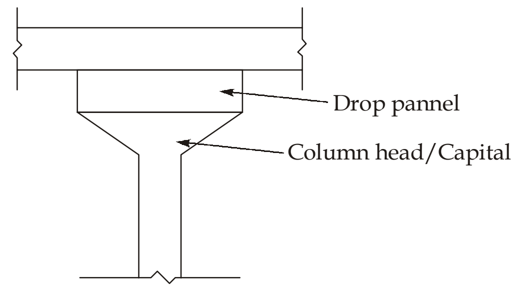
$$? = \frac{1000 \times \frac{\pi}{4}(12)^2}{A_{st}} \quad ...(2)$$

From eq. (1) and eq. (2)

$$\frac{10}{?} = \frac{(10)^2}{(12)^2}$$

$$? = \frac{(12)^2 \times 10}{(10)^2} = 14.4 \text{ cm}$$

13. (a)



14. (c)

- Isolated footing bends in saucer like shape under cantilever action.
- In strap footings dowels are used such that strap and footing acts as a unit.

15. (c)

Minimum depth of footing,

$$D_{min} = \frac{q}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2 = \frac{130}{18.5}\left(\frac{1-\sin 30}{1+\sin 30}\right)^2 = 0.78 \text{ m}$$

16. (b)

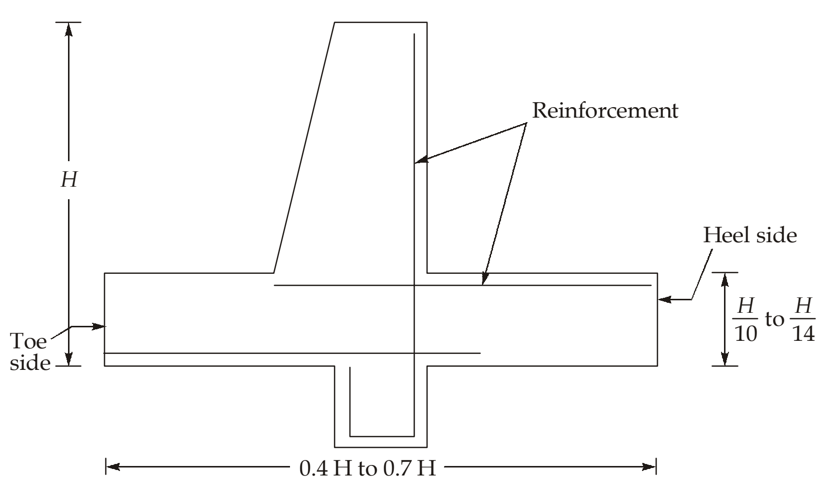
Maximum pitch or maximum spacing of lateral ties shall be minimum of

- Least lateral dimension = 400 mm.
- 16 times small dia. bars = 16 × 12 = 192 mm
- 300 mm

Hence, maximum spacing will be 192 mm.

17. (d)

The base width of retaining wall of height H is generally varies from 0.4 – 0.7 times the height of wall.



18. (b)

As maximum hoop tension will develop at bottom and is given by

$$\frac{\gamma_w H.D}{2} = \frac{10\times3\times2}{2} = 30 \text{ kN/m}$$

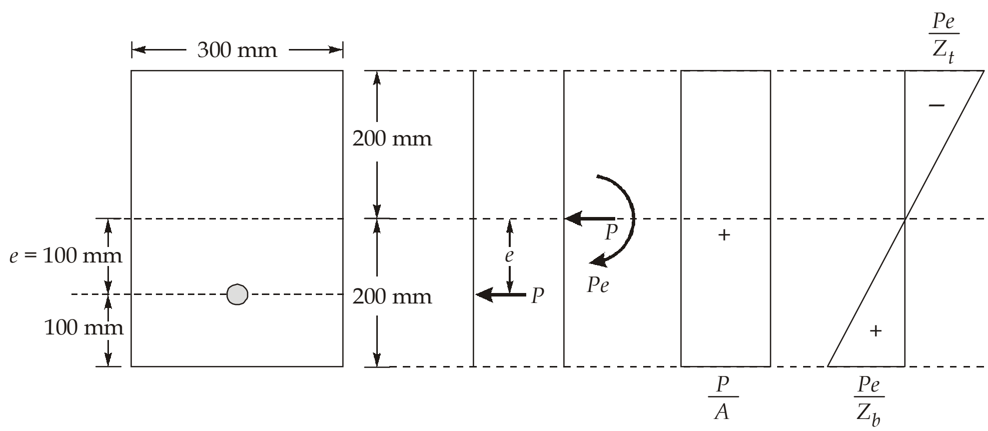
22. (b)

The limiting principle tensile stress in an uncracked prestressed concrete member is given by

$$f_t = 0.24\sqrt{f_{ck}}$$

$$= 0.24\sqrt{30} = 1.32 \text{ N/mm}^2$$

23. (c)



Given final prestressing force = 1000 kN

losses = 20%

$$\therefore \quad P\left(1-\frac{P_L\%}{100}\right) = 1000$$

$$P = \frac{1000}{(1-0.2)} = \frac{1000}{0.8} = 1250 \text{ kN}$$

Now, stresses at top and bottom fibre,

$$f_{t/b} = \frac{P}{A} \mp \frac{Pe}{(z_{t/b})}$$

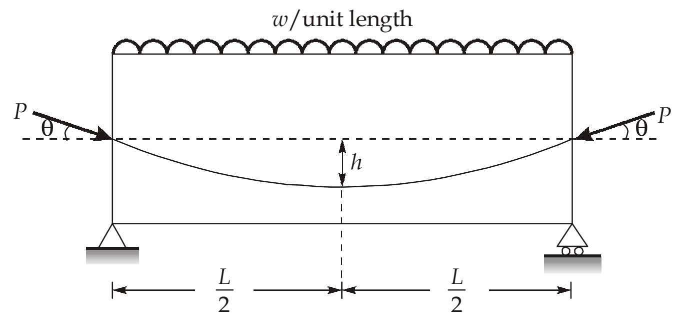
$$= \frac{1250\times10^3}{300\times400} \mp \frac{1250\times10^3\times100}{\frac{300\times(400)^2}{6}}$$

$$= 10.416 \mp 15.625$$

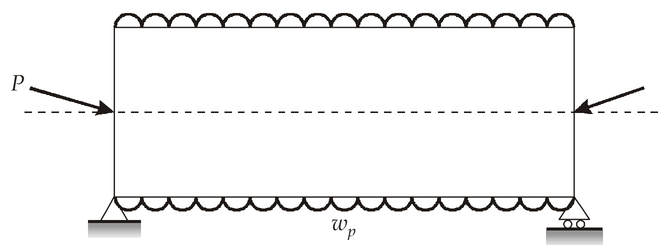
$$f_t = 10.416 - 15.625 = -5.209 \text{ N/mm}^2$$

$$f_b = 10.416 + 15.625 = 26.041 \text{ N/mm}^2$$

24. (b)



Applying load balancing concept,



$$w_p = \frac{8Pe\cos\theta}{L^2} \qquad \text{Here, (θ very – 2 small)}$$

$$\therefore \quad w_p = \frac{8Ph}{L^2}$$

25. (c)

As per IS 1343, clause 19.3.2. on the basis of cracking, sections are divided into three class.

Class-I: No tensile stress on the section.

Class-II: Tensile stresses are allowed, but not visible cracking, maximum upto 3 N/mm^2.

Class-III: Cracking is permitted but it should not affect the appearance of the member.

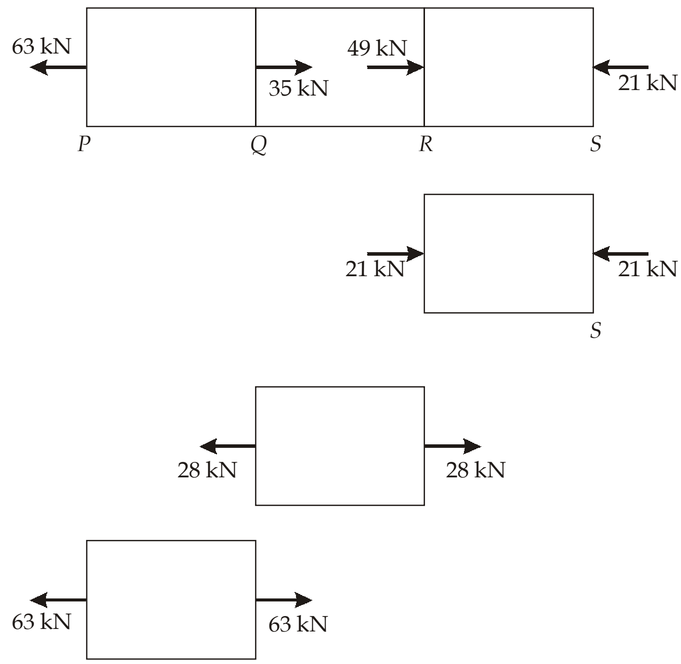
26. (c)

Explanation, loss of prestress due to anchorage slip

$$= \frac{\Delta}{L}E_s = \frac{4}{25000}\times 210\times 10^3 = 33.6 \text{ N/mm}^2$$

$$\text{\%age loss} = \frac{33.6}{1200}\times 100 = 2.8\%$$

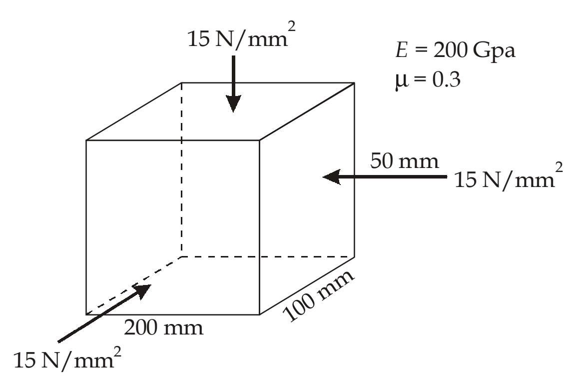
28. (a)



For segment '*QR*'

$$\text{Stress, } \sigma = \frac{28 \times 10^3}{700} = 40 \text{ N/mm}^2 = 40 \text{ MPa}$$

29. (b)

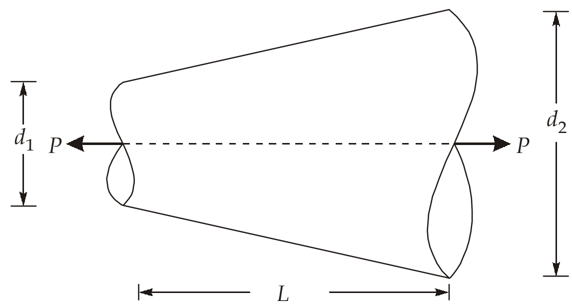


$$\varepsilon_v = \frac{3\sigma}{E}(1-2\mu) = \frac{3 \times 15}{200 \times 10^3}(1-2 \times 0.3)$$

$$\frac{dv}{V} = \frac{45 \times 0.4}{200 \times 10^3}$$

$$\therefore \quad dV = \frac{45 \times 0.4}{200 \times 10^3} \times (200 \times 100 \times 50) = 90 \text{ mm}^3$$

30. (a)



$$\delta = \frac{4PL}{\pi E d_1 d_2}$$

32. (a)

$$\frac{\gamma_{max}}{2} = \frac{\varepsilon_1 - \varepsilon_2}{2}$$

$$\gamma_{max} = \varepsilon_1 - \varepsilon_2 = 100 \times 10^{-6} - (-200 \times 10^{-6}) = 300 \times 10^{-6}$$

33. (b)

$$M = 1.2T$$

$$\tau_{max} = \frac{16}{\pi D^3}\sqrt{M^2 + T^2}$$

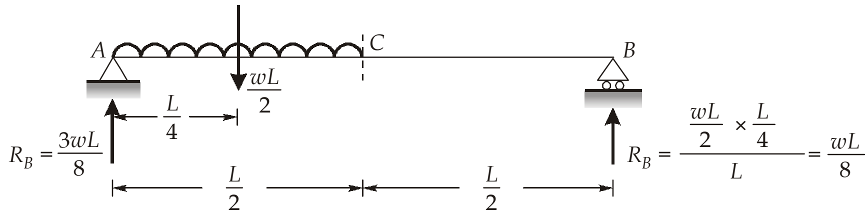
$$\sigma_{max} = \frac{16}{\pi D^3}\left(M + \sqrt{M^2 + T^2}\right) \qquad (M = 1.2T)$$

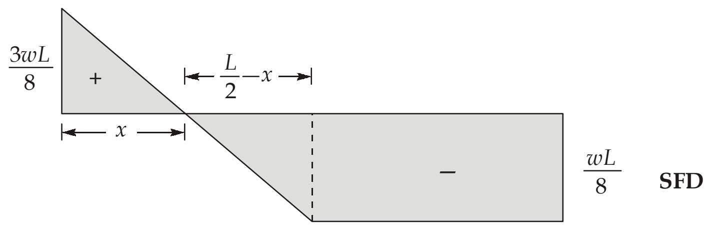
$$\frac{\tau_{max}}{\sigma_{max}} = \frac{\sqrt{M^2 + T^2}}{M + \sqrt{M^2 + T^2}} = \frac{\sqrt{(1.2T)^2 + (T^2)}}{1.2T + \sqrt{\left((1.2)^2 + 1\right)T^2}} = 0.566$$

34. (a)

First time integration of load intensity curve gives SFD curve of degree (n + 1), second time integration of load intensity curve gives BMD curve of degree (n + 2).

35. (c)





$$\frac{x}{\frac{3wL}{8}} = \frac{(L/2-x)}{\frac{wL}{8}}$$

$$\frac{x}{3} = \frac{L}{2}-x$$

$$\frac{4x}{3} = \frac{L}{2}$$

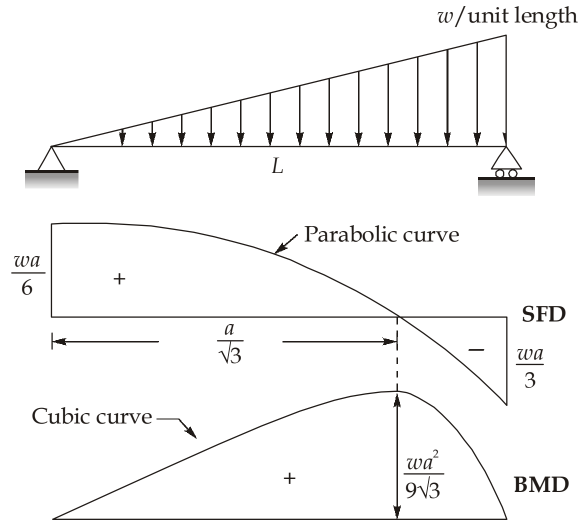
$$\therefore \quad x = \frac{3L}{8}$$

$V_C - V_A$ = Area under loading intensity between C and A.

$$V_C - \frac{3wL}{8} = -\left(\frac{wL}{2}\right)$$

$$V_C = \frac{3wL}{8}-\frac{wL}{2} = \frac{3wL-4wL}{8} = \frac{-wL}{8}$$

36. (d)



37. (c)

$$P_{cr} = \frac{\pi^2 EI}{L_{eff}^2}$$

$$\Rightarrow \quad P_{cr} \propto \frac{1}{(L_{eff})^2}$$

Case : 1

Column fixed at both ends, $L_{eff} = \frac{L}{2}$

Case : 2

Column hinged at both ends, $L_{eff} = L$

Now, ratio,

$$\frac{(P_{cr})_1}{(P_{cr})_2} = \frac{1/(L/2)^2}{1/L^2} = 4$$

38. (c)

By Rankine crieteriorn of failure.

$$\frac{1}{P_R} = \frac{1}{P_E} + \frac{1}{P_C}$$

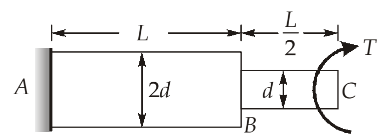
$$\Rightarrow \quad P_R = \frac{P_C \cdot P_E}{P_E + P_C}$$

39. **(c)**

Rankine formula is applicable for both short and long column. Hence failure by both crushing and buckling has been accounted in this case.

Note: Euler's formula is valid for long columns only.

40. **(b)**



$$\theta_{CA} = \theta_{CB} + \theta_{BA}$$

$$\theta_C - \theta_A = \theta_{CB} + \theta_{BA}$$

$$\theta_C = \frac{TL/2}{G\frac{\pi(d)^4}{32}} + \frac{TL}{\frac{G\pi(2d)^4}{32}}$$

$$= \frac{TL}{G\frac{\pi d^4}{32}}\left(\frac{1}{2}+\frac{1}{16}\right) = \frac{TL}{\frac{G\pi d^4}{32}}\left(\frac{8+1}{16}\right)$$

$$\theta = \frac{18TL}{G\pi d^4}$$

$$\therefore \quad d^4 = \frac{18TL}{G\pi\theta}$$

$$d = \left(\frac{18TL}{G\pi\theta}\right)^{1/4}$$

41. **(a)**

Equivalent moment:

$$M_{eq} = \frac{1}{2}\left(M+\sqrt{M^2+T^2}\right)$$

$$= \frac{1}{2}\left(400+\sqrt{(400)^2+(300)^2}\right) = \frac{1}{2}(400+500) = 450 \text{ Nm}$$

$$\text{Equivalent torque, } T_{eq} = \sqrt{M^2+T^2} = \sqrt{(400)^2+(300)^2} = 500 \text{ Nm}$$

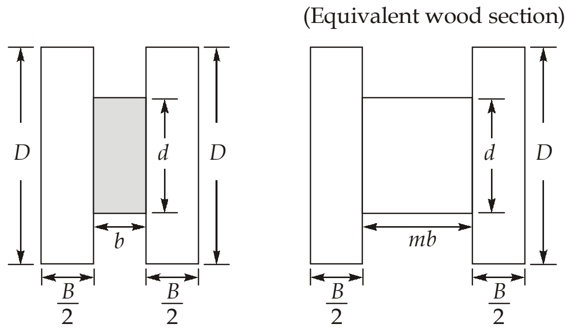
42. **(a)**

For maximum flexural stress, point load should be placed at mid span.

$$M_{max} = \frac{FL}{4}$$

$$\therefore \quad \sigma_{max} = \frac{M_{max}}{I}y_{max} = \frac{FL/4}{(BD^2/6)} = \frac{3}{2}\frac{FL}{BD^2}$$

43. (b)



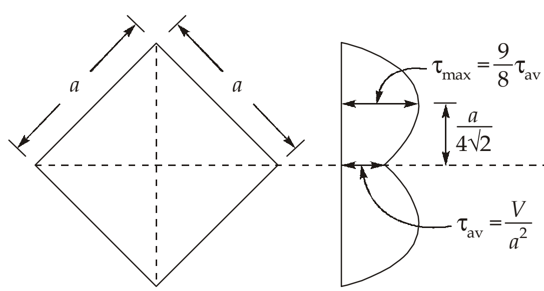
$$I_{eq} = 2\times\left(\frac{B/2\times D^3}{12}\right)+\frac{mbd^3}{12}$$

$$= \frac{BD^3}{12}+\frac{mbd^3}{12}$$

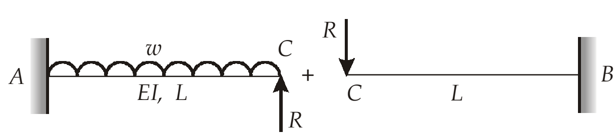
$$\text{MOR} = \frac{\sigma}{y_{\max}}\times I_{eq}$$

$$= \frac{\sigma}{D/2}\times\left(\frac{BD^3+mbd^3}{12}\right)=\left(\frac{BD^3+mbd^3}{6D}\right)\sigma$$

44. (a)



46. (a)



Downward deflection of point C in beam AC = Downward deflection of point C in beam CB.

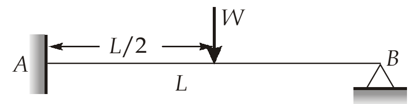
$$\frac{wL^4}{8EI}-\frac{RL^3}{3EI} = \frac{RL^3}{3EI}$$

$$\frac{2RL^3}{3EI} = \frac{wL^4}{8EI}$$

$$R = \frac{3wL}{16}\text{ kN}$$

47. (b)

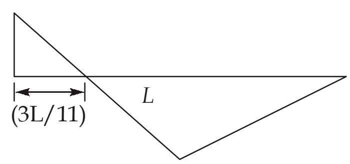
1.



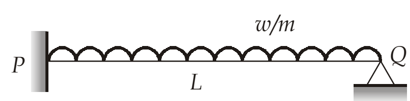
- $$R_B = \frac{5W}{16}$$

Point of contraflexure at $\frac{3L}{11}$ from fixed support.

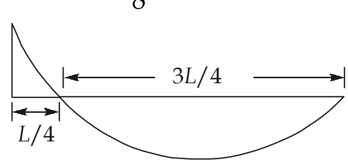
- $$M_A = \frac{-3WL}{16} \text{ (hogging)}$$
- $$BM_{max} = \frac{5WL}{32} \text{(sagging)}$$



2.



- $$R_Q = \frac{3wL}{8}$$
- $$\text{Maximum +ve BM} = \frac{9wL^2}{128}$$
- $$\text{Support moment} = \frac{wL^2}{8} \text{ (hogging)}$$



49. (c)

Critical path defines the longest duration needed to complete the project and it also defines the shortest permissible duration before which project cannot be completed.

50. (a)

5 'E' safety programme.

- Engineering.
- Education.
- Encouragement.
- Enforcement.
- Evaluation.

51. (a)

ABC analysis is a selective inventory management technique that classifies materials into class *A*, *B* and *C* based on their annual usage value.

A = high usage value items
B = Moderate usage value items
C = Low usage value items

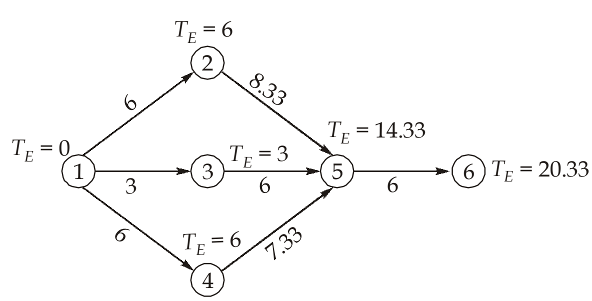
52. (a)

- Six sigma is a set of techniques and tools for process improvement. It was introduced by engineer bill smith while working at motorola in 1986.
- A six sigma is one in which 99.99966% of all opportunities to produce some feature of a part are statically free of defects i.e. six sigma process will give 3.4 defects per million opportunities (DPMO).

53. (d)

$$t_E = \frac{t_o + 4t_m + t_p}{6}$$

Activity	t_E
1 – 2	6
1 – 3	3
1 – 4	6
2 – 5	8.33
3 – 5	6
4 – 5	7.33
5 – 6	6



Critical path – (1 – 2 – 5 – 6)

∴ Expected time of project = 20.33

58. (c)

Intrusive igneous rock made from cooling of solidification of magma.
Ex.: Granite, pegmatite, peridotite, diorite.

59. (b)

Snowcrete is one of the patent form of water proof cement point.

61. (c)

ASCu is a preservative composed of

$$AS_2O_5\ 2H_2O \rightarrow 1 \text{ part by weight}$$
$$AS_2O_5\ 5H_2O \rightarrow 3 \text{ part by weight}$$
$$k_2Cr_2O_7/Na_2Cr_2O_7\ 2H_2O \rightarrow 4 \text{ part by weight}$$

62. (c)

The proportion of various ingredients of bricks are as follows:

Silica → 50 – 60%
Alumina → 20 – 30%
Lime → 10%
Magnesia → 1%

63. (a)

(Gauged morter)/(Lime cement morter) is a mixture of sand, cement and lime in different proportions. It makes lime mortar economical, strong and dense.

64. (b)

By this process the core of specimen is kept tough and ductile while the surface is made hard by increasing the carbon content near surface.

65. (a)

IS : 10262 - Concrete mix proportioning guidelines.
IS : 13920 - Ductile detailing of reinforced concrete structures subjected to seismic forces-codes of practice.
IS : 383 - Specification for coarse and fine aggregates from natural source for concrete.
IS : 456 - Natural sources for concrete plain and reinforced concrete for practice.

66. (c)

Green concrete:
- Concrete which is made from wastes that are ecofriendly is called as green concrete.
- Blast furnace slag, iron oxides and flyash are common ingredients of green concrete.

67. (d)

68. (b)

The various tests and their uses are tabulated below.

(Type of test)	Use
1. i. Air permeability test ii. Sieve method. iii. Sedimentation test.	To measure degree of fineness of cement.
2. Vicat's apparatus test	To measure consistency of cement and setting time of cement
3. i. Le-chatalier method ii. Autoclave test	To measure soundness of test
4. Briquette method	To determine tensile strength of cement
5. Crushing test	To determine compressive strength of cement

69. (d)

- **Reveal**: It is the external jamb of a or window opening at right angles to the wall face.
- **Horn**: These are the horizontal projections of the head and sill of a frame to facilitate the fixing of the frame on the wall opening. The length of horns is kept about 10 to 15 cm.
- **Style**: Style is the vertical outside member of the shutter of a door or window.

70. (d)

Residential building – Group A
Educational building – Group B
Institutional building – Group C

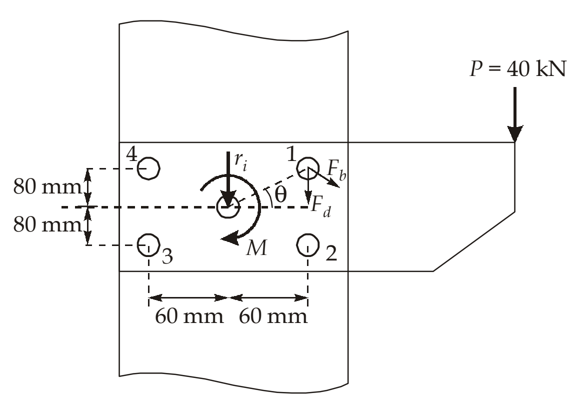
73. (b)

- **Eaves**: The lower edge of the inclined roof surface is called eaves.
- **Valley**: It is a reverse of a hip. It is formed by the intersection of two roofs surfaces, making an exterior angle less than 180°.
- Verge: The edge of a gable running between the eaves and a ridge is called, a verge.

74. (a)

S. No.	Definition	Partial safety factor
1.	Resistance, governed by yielding (γ_{mo})	1.1
2.	Resistance of member to buckling (γ_{mo})	1.1
3.	Resistance, governed by ultimate stress (γ_{m1})	1.25

78. (a)



$$M = 40 \text{ kN} \times 250 \text{ mm}$$

$$r_i = \sqrt{(80)^2 + 60^2} = 100 \text{ mm}$$

$$\Sigma r_i^2 = 4 \times (100)^2 + 0 = 4 \times (100)^2 \text{ mm}^2$$

Bolt 1 and 2 is critical bolt. Direct shear force on the bolt $(F_d) = \frac{P}{n} = \frac{40}{5} = 8$ kN

Now, force in bolt due to moment

$$F_b = \frac{Pe}{\Sigma r_i^2} r_i$$

$$= \frac{40\,\text{kN} \times 250\,\text{mm} \times 100\,\text{mm}}{4 \times (100)^2\,\text{mm}^2} = 25\text{ kN}$$

$$\cos\theta = \frac{60}{100} = 0.6$$

Now, total shear force on the extreme bolt

$$F_R = \sqrt{F_d^2 + F_b^2 + 2F_d F_b \cos\theta}$$

$$= \sqrt{(8)^2 + (25)^2 + 2 \times 8 \times 25 \times 0.6} = 30.48\text{ kN}$$

81. (a)

To avoid buckling of compression flange, IS 800 - 2007 specifies following web thickness requirements:

When transverse stiffeners are not provided

$$\frac{d}{t_w} \leq 345\varepsilon_f^2$$

82. (c)

Design shear capacity:

$$V_d = \frac{f_y}{\sqrt{3}\gamma_{mo}} h t_w$$

$$= \frac{250}{\sqrt{3} \times 1.1} \times 200 \times 5.4 \times 10^{-3} = 141.7\text{ kN} \simeq 142\text{ kN}$$

83. (b)

Slope of roof : $\theta = 30° > 10°$

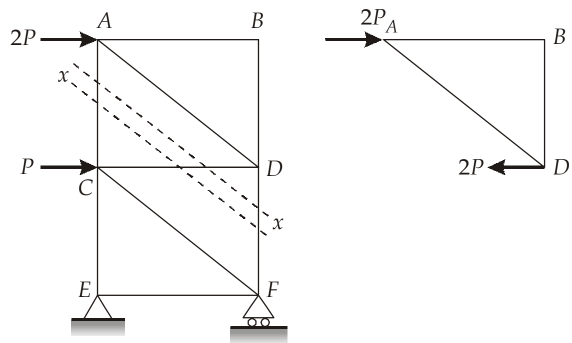
Now, Imposed load $= (750 - 20(\theta - 10))\ \text{N/m}^2$

$= (750 - 20(30 - 10))\ \text{N/m}^2$

$= 350\ \text{N/m}^2 \nless 400\ \text{N/m}^2$

Minimum imposed load on the roof is 400 N/m^2.

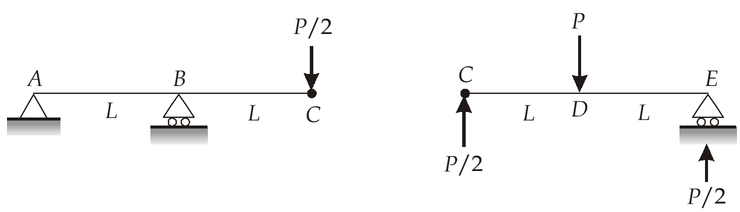
86. **(b)**



Consider the section *x-x* and consider upper part of it.

$$F_{CD} = 2P\text{(tensile)}$$

87. **(b)**



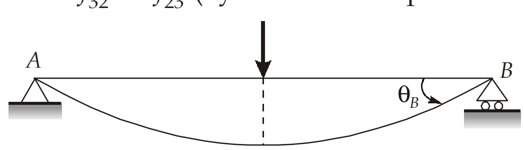
$$\Delta_c = \frac{(P/2)\times L^3}{3EI} + \frac{(PL/2)L\times L}{3EI} = \frac{PL^3}{3EI}$$

As *CE* is rigid,

$$\delta_D = \frac{\delta_c}{2} = \frac{PL^3}{3EI\times 2} = \frac{PL^3}{6EI}$$

89. **(d)**

$$f_{32} = f_{23} \text{ (by Maxwell reciprocal theorem)}$$

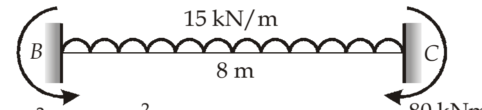


$$\theta_B = \frac{L^2}{16EI}$$

$$\therefore \quad f_{23} = \frac{-L^2}{16EI}$$

$$\therefore \quad f_{32} = \frac{-L^2}{16EI}$$

90. (a)



$$\frac{wL^2}{12} = \frac{15 \times (8)^2}{12}$$

$$\frac{wL^2}{12} = \frac{15\times(8)^2}{12}$$

$\therefore \quad M_{FBC} = -80$ kNm, $M_{FCB} = 80$ kNm

For span *BC* (Slope deflection equation)

$$M_{BC} = M_{FBC} + \frac{2EI}{8}\left(2\theta_B + \theta_C - \frac{3\delta}{L}\right)$$

$$= -80 + 0.25EI(2\theta_B + \theta_C)$$

91. (b)

Joint	Member	Member Stiffness (MS)	Joint Stiffness (JS)	DF = $\frac{MS}{JS}$
B	*BA*	$\frac{4EI}{8}$	*EI*	0.5
	BC	$\frac{3EI}{6}$		0.5

93. (c)

Two hinged arch is an indeterminate structure with the increase in temperature, the horizontal thrust at the supports of the arch increases. As the crown is at maximum distance from horizontal support, the maximum bending moment increase is at crown.

96. (b)

$$\text{Flywheel energy} = \int_0^{2\pi} T d\theta$$

By using Simpson's rule

$$\int_0^{2\pi} T d\theta = \frac{h}{3}\left[(y_o + y_n) + 4(y_1 + y_3 + ...) + 2(y_2 + y_4 + ...)\right]$$

$$= \frac{\pi/3}{3}[(0+0) + 4(1066 + 0 - 355) + 2(-323 + 323)]$$

$$= \frac{\pi}{9} \times 4 \times 711 = 992.743 \simeq 993 \text{ J}$$

97. (c)

$$f(x) = x^3 + x - 1$$

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{x_n^3 + x_n - 1}{3x_n^2 + 1} = \frac{3x_n^3 + x_n - x_n^3 - x_n + 1}{3x_n^2 + 1}$$

$$x_{n+1} = \frac{2x_n^3 + 1}{3x_n^2 + 1}$$

$$x_0 = 1$$

$$x_1 = \frac{2x_0^3 + 1}{3x_0^2 + 1} = \frac{2 \times 1 + 1}{3 \times 1 + 1} = \frac{3}{4} = 0.750$$

99. (a)

Rewriting the equation as

$$x_1 = 0.3 + 0.2x_2 + 0.1x_3 + 0.1x_4 \quad ...(1)$$
$$x_2 = 1.5 + 0.2x_1 + 0.1x_3 + 0.1x_4 \quad ...(2)$$
$$x_3 = 2.7 + 0.1x_4 + 0.1x_2 + 0.2x_4 \quad ...(3)$$
$$x_4 = -0.9 + 0.1x_1 + 0.1x_2 + 0.2x_3 \quad ...(4)$$

First iteration,

Putting $x_2 = 0$, $x_3 = 0$, $x_4 = 0$, in eq. (1), we get

$$x_1 = 0.3$$

Putting $x_1 = 0.3$, $x_3 = 0$, $x_4 = 0$, in eq. (2), we get

$$x_2 = 1.56$$

Putting $x_2 = 1.56$, $x_1 = 0.3$, $x_4 = 0$, in eq. (3), we get

$$x_3 = 2.7 + 0.1 \times 0.3 + 0.1 \times 1.56 + 0 = 2.886$$

Putting $x_1 = 0.3$, $x_2 = 1.56$, $x_3 = 2.886$

$$x_4 = -0.9 + 0.1 \times 0.3 + 0.1 \times 1.56 + 0.2 \times 2.886 = -0.1368$$

100. (c)

■■■■